MECHANISMS FOR FORMING IMAGE SENSOR DEVICE

BACKGROUND

The semiconductor integrated circuit (IC) has experienced rapid growth. Technological advances in IC materials and design have produced generations of ICs where each generation has smaller and more complex circuits than the previous generation. In the course of IC evolution, functional density (i.e., the number of interconnected devices per chip area) has generally increased while geometric size (i.e., the smallest component that can be created using a fabrication process) has decreased. Such advances have increased the complexity of processing and manufacturing ICs. For these advances, similar developments in IC processing and manufacturing are needed.

Along with the advantages realized from reducing geometry size, improvements are being made directly to the IC devices. One such IC device is an image sensor device. An image sensor device includes a pixel array (or grid) for detecting light and recording intensity (brightness) of the detected light. The pixel array responds to the light by accumulating a charge. The higher the intensity of the light is, the higher the charge is accumulated in the pixel array. The accumulated charge is then used (for example, by other circuitry) to provide image information for use in a suitable application, such as a digital camera.

However, since the feature sizes continue to decrease, fabrication processes continue to become more difficult to perform. Therefore, it is a challenge to form reliable image sensor devices with smaller and smaller sizes.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the illustrative embodiments and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings.

FIG. **1** is a top view of an image sensor device, in accordance with some embodiments.

FIG. **2** is an enlarged top view of a pixel region in an image sensor device, in accordance with some embodiments.

FIG. **3** is a cross-sectional view of an image sensor device, in accordance with some embodiments.

FIGS. **4A-4E** are cross-sectional views of a process for forming an image sensor device, in accordance with some embodiments.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

The making and using of various embodiments of the disclosure are discussed in detail below. It should be appreciated, however, that the various embodiments can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative, and do not limit the scope of the disclosure.

It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of the disclosure. Specific examples of components and arrangements are described below to simplify the present disclosure. These are merely examples and are not intended to be limiting. Moreover, the performance of a first process before a second process in the description that follows may include embodiments in which the second process is performed immediately after the first process, and may also include embodiments in which additional processes may be performed between the first and second processes. Various features may be arbitrarily drawn in different scales for the sake of simplicity and clarity. Furthermore, the formation of a first feature over or on a second feature in the description that follows include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact.

Some variations of the embodiments are described. Throughout the various views and illustrative embodiments, like reference numbers are used to designate like elements.

FIG. **1** is a top view of an image sensor device **100**, in accordance with some embodiments. The image sensor device **100** may be a backside illuminated (BSI) image sensor device. However, it should be appreciated that embodiments of the disclosure are not limited thereto. In some other embodiments, the image sensor device **100** is a front side illuminated (FSI) image sensor device.

In some embodiments, the image sensor device **100** includes an array of pixel regions **101**. The pixel regions **101** may be arranged into a column (for example, C_1 to C_X) and a row (for example, R_1 to R_Y). The term "pixel region" refers to a unit cell containing features (for example, a photodetector and various circuitry). The unit cell may include various semiconductor devices for converting electromagnetic radiation into an electrical signal. Photodetectors in the pixel regions **101** may include photodiodes, complimentary metal-oxide-semiconductor (CMOS) image sensors, charged coupling device (CCD) sensors, active sensors, passive sensors, other applicable sensors, or a combination thereof.

The pixel regions **101** may be designed having various sensor types. One group of pixel regions **101** may be CMOS image sensors, and another group of pixel regions **101** may be other types of sensors, such as passive sensors. In some embodiments, each pixel region **101** includes a photodetector, such as a photogate-type photodetector, for recording intensity or brightness of light (radiation). Each pixel region **101** may also include various semiconductor devices, such as various transistors.

Additional circuitry, inputs, and/or outputs may be formed in a peripheral region of the image sensor device **100** and be coupled to the pixel regions **101**. The circuitry in the peripheral region provides an operation environment for the pixel regions **101** and support external communications with the pixel regions **101**.

FIG. **2** is an enlarged top view of one of the pixel regions **101** of the image sensor device **100** on a front surface of a semiconductor substrate (not illustrated in FIG. **2**), in accordance with some embodiments. As shown in FIG. **2**, the pixel region **101** includes a photodetector **106**. In some embodiments, the photodetector **106** includes a photodiode for recording intensity or brightness of light (radiation). The pixel region **101** may contain various transistors. For example, the transistors include a transfer transistor **110**, a reset transistor **112**, a source-follower transistor **114**, a select transistor **116**, other suitable transistors, or a combination thereof.

The pixel region **101** may also include various doped regions in the semiconductor substrate, such as doped regions **118**A, **118**B, and **120**. The doped regions **118**A, **118**B, and **120** serve as source/drain regions of the previously mentioned transistors. The doped region **120** is also